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C.H. HUCKELBERRY
County Administrator

December 17, 2015

Robert A. Leidy, Ph.D.
Ecologist/Enforcement Officer
U.S. Environmental Protection Agency
Wetlands Office (WTR-2-4)
75 Hawthorne Street
San Francisco, California 94105

Re: **Rosemont Mine – Surface Water Impacts, Davidson Canyon and Cienega Creek**

Dear Dr. Leidy:

Please find the attached December 13, 2015 memorandum by Pima County staff regarding recent analysis of surface water inputs to Davidson Canyon. These data provide much-needed review of impacts of the proposed Rosemont Mine on the surface waters of Davidson Canyon and Cienega Creek. The analysis relies on a new data source: the Regional Flood Control District's installation of an automated data logger in the Davidson #2 Well, which has enabled a closer look at the responsiveness of the water table and the relationship with Davidson Canyon stream flow length. More specifically, staff found that:

- Barrel Canyon provides a disproportional amount of surface water within the Davidson Canyon watershed;
- The shallow groundwater aquifer in Davidson Canyon is highly responsive to pulses of surface water flow. (Further analysis of winter precipitation in 2015 and 2016 using a new dataset at the Davidson #2 Well (intra-day well depths) will provide valuable insight into this important relationship);
- A new analysis of the relationship between depth to water and length of streamflow in Davidson Canyon reaffirms an earlier analysis of a strong statistical relationship between these two variables. That is, as groundwater levels rise and fall, so, too, does the length of flow in Davidson Canyon increase and contract.

Failure to understand the connection between surface water in Davidson Canyon and to account for its loss because of surface water diversions by the Rosemont Mine could lead to irreparable harm to groundwater resources that are critical to the proper hydrological conditions and functions that sustain vegetation and surface water and to the wildlife that depend on these critical resources.

Thank you for consideration of this new information.

Sincerely,

C. Huckelberry

C.H. Huckelberry
County Administrator

CHH/anc

Enclosure

c: Linda Mayro, Director, Sustainability and Conservation
Suzanne Shields, Director, Regional Flood Control District

PIMA COUNTY
SUSTAINABILITY & CONSERVATION

Memorandum

Date: December 13, 2015

To: Linda Mayro, Director, Office of Sustainability and Conservation;
Suzanne Shields, Director, Pima County Regional Flood Control District

From: Brian Powell, Program Coordinator, Office of Sustainability and Conservation;
Julia Fonseca, Environmental Planning Manager, Office of Sustainability and Conservation;
Frank Postillion, Pima County Regional Flood Control District

RE: New analysis of stormflow and groundwater data from Davidson Canyon: Evidence for influence of stormwater recharge of groundwater

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If constructed, the proposed Rosemont mine will have a host of negative environmental effects for which Pima County staff have focused numerous previous comments (e.g., Pima County 2012, 2013; Huckelberry 2014; Powell et al. 2014). Many issues raised by Pima County remain a concern, including the mine's impact on stormwater flows to Davidson Canyon and Cienega Creek and resulting impacts on surface water extent, groundwater recharge, vegetation, and the species that rely on these resources.

Past analysis by Pima County staff (Powell et al. 2014) focused on the groundwater declines on Cienega Creek and Davidson Canyon and connected observations of well depth to flow measurements made at Marsh Station and to length of streamflow in Cienega Creek and Davidson Canyon. This analysis showed an exceptionally strong relationship between length of surface water flow of Davidson Canyon and depth to groundwater. Modeling of this relationship showed that reduction in groundwater would have a concomitant impact on streamflow length; by one estimate as much as a 30% reduction in flow length (Powell et al. 2014).

The impacts of the proposed Rosemont mine on stormwater and baseflows to Davidson Canyon have been understated in both the final environmental impact statement (U.S. Forest Service 2013) and the draft water quality certification by the Arizona Department of Water Quality (Arizona Department of Environmental Quality 2014). The understated impacts were then carried through to the draft biological opinion (U. S. Fish and Wildlife Service 2013). In the County's comments to the Arizona Department of Environmental

Quality (Huckelberry 2014), the County identified the need for more information on stormwater impacts to Davidson Canyon. The County's recent analysis (Powell et al. 2014) provided additional evidence that the runoff-recharge relationship in Davidson Canyon is strong, and cutting off upstream contributions to the watershed would be detrimental to the sustenance of surface and shallow groundwater which sustains hydroriparian habitat in the Creek, and is a large reason for its Arizona Outstanding Waters designation.

This current memorandum focuses on looking closely at a new dataset for the Davidson #2 Well (Arizona Department of Water Resources Well Registry #808500) and depth to water as a function of stormflow (cubic feet per second; CFS) at the Davidson Canyon ALERT gauge (#4313), stormflow events at the gauge, and surface water measured at the Barrel Canyon USGS Gauge (#94845680).

Davidson #2 Well is situated approximately 150 feet west of ALERT gauge #4313 and across Davidson Creek (Figure 1). Prior to a new pressure transducer installation it was measured for water levels on a monthly basis with an electrical well sounder. New data from the Davidson #2 Well, which is not pumped and is a monitoring well, comes from the installation of an automated water level depth sensor (pressure transducer) on July 17, 2015; the sensor records depth to water (DTW) four times each day. By contrast, the USGS and Pima County ALERT gauges record data every hour and ALERT gauge reporting is triggered by a stormwater event (see next paragraph). The period of record for most of the analysis in this memorandum is from July 16, 2015 to November 24, 2015.

We compared the DTW to four separate storm events recorded at the Davidson Canyon ALERT gauge. Unlike USGS streamflow discharge gauges, which record all surface flow, the ALERT gauges record only stormflow events that exceed a certain stage. Stage height at both gauges is in turn related to discharge using rating curves developed at each site. For both gauges we used the mean daily CFS as the explanatory variable in the statistical models.

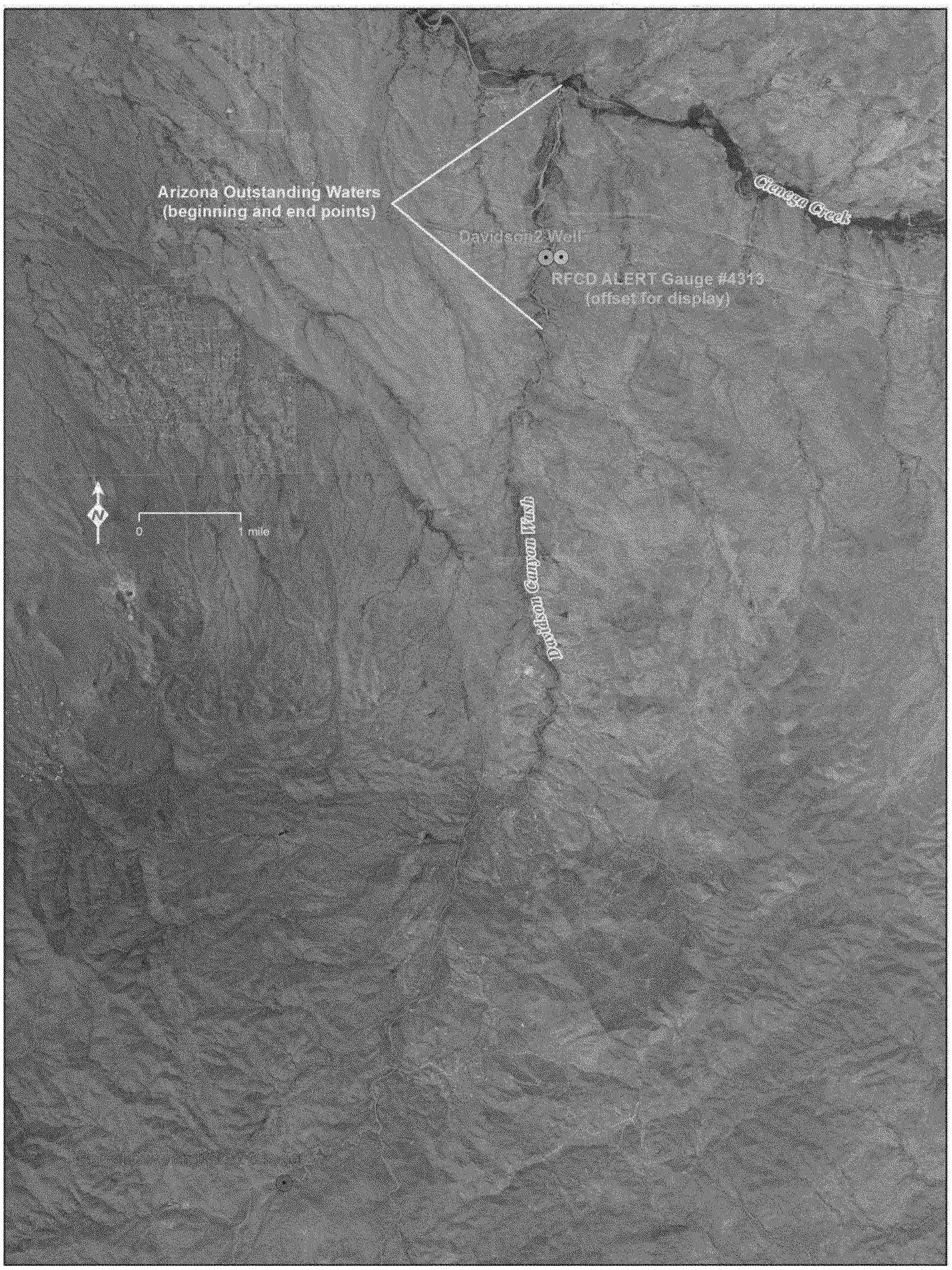

Figure 1. Location of key features related to the current analysis, Davidson Canyon, Pima County, Arizona.

Streamflow Accounting: Barrel Canyon provides a disproportional amount of runoff to Davidson Canyon. The watershed area above the Davidson Canyon Gauge is 32,320 acres, while the area above the Barrel Canyon Gauge is 9,024 acres, 28% of the watershed area of the Davidson gauge. For the period of time that is the focus of this analysis (July 15-November 25), a total of 470 acre feet of stormwater were recorded at the Davidson Canyon gauge. At the Barrel Canyon Gauge 186 acre feet were recorded, 39% of the amount recorded at the Davidson Canyon Gauge. This suggests that the Barrel watershed yields more water than its proportional area within the Davidson watershed. The EIS discussion does not take into account the higher elevation difference of the Barrel watershed and the increased rainfall and runoff of the watershed, and thus underestimates the flow contribution of the Barrel watershed to Davidson Canyon.

Importance of Streamflow to Aquifer Recharge in Davidson Canyon. In this next analysis, we compare the daily change in well depth at Davidson #2 Well to stormwater flows in Davidson Canyon (Fig. 2), baseflow at Barrel Canyon (Fig. 3) and Barrel and Davidson canyon stormflow (Fig. 4).

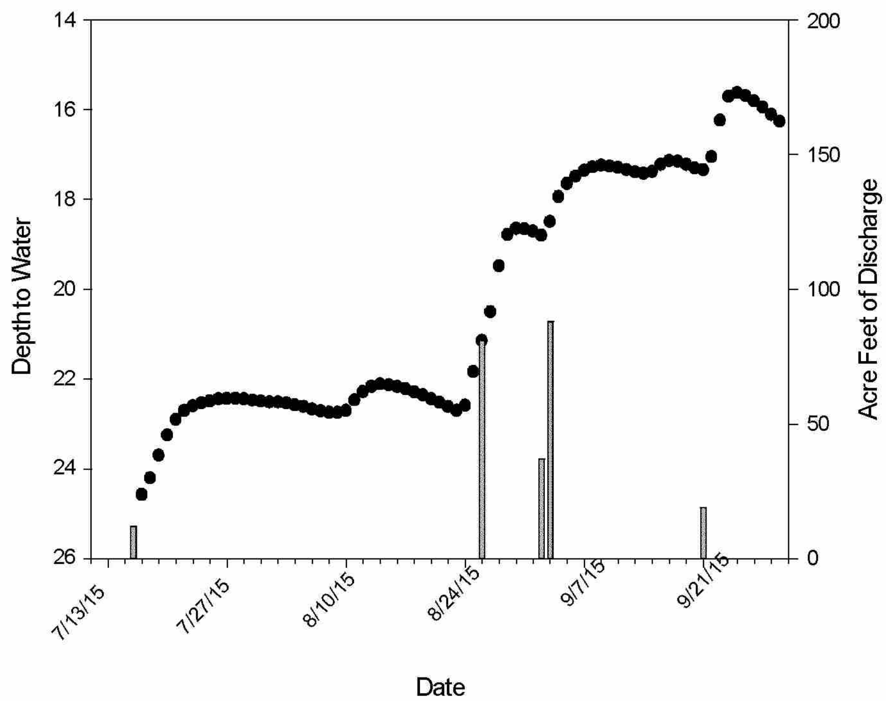

Figure 2. Change in depth to water (feet) at the Davidson #2 Well (black dots) in relationship to stormflow at the Davidson Canyon Gauge, 2015.

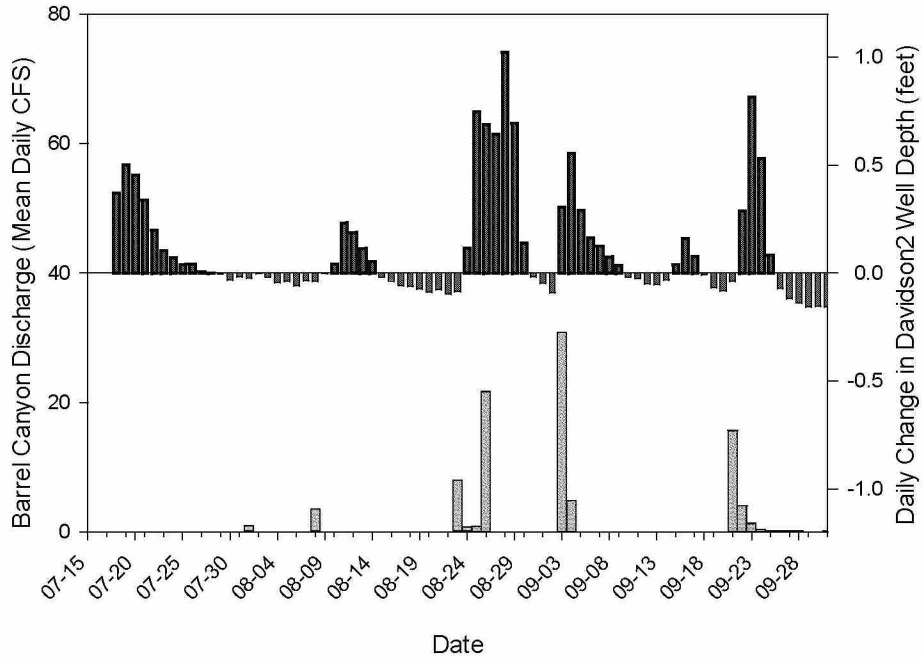

Figure 3. Daily change in depth to water (feet) at the Davidson #2 Well (colored bars) in relationship to flow measured at Barrel Canyon USGS gauge (grey bars), 2015. Daily change is calculated by subtracting average daily well depth (for a particular day) by the average depth for the previous day.

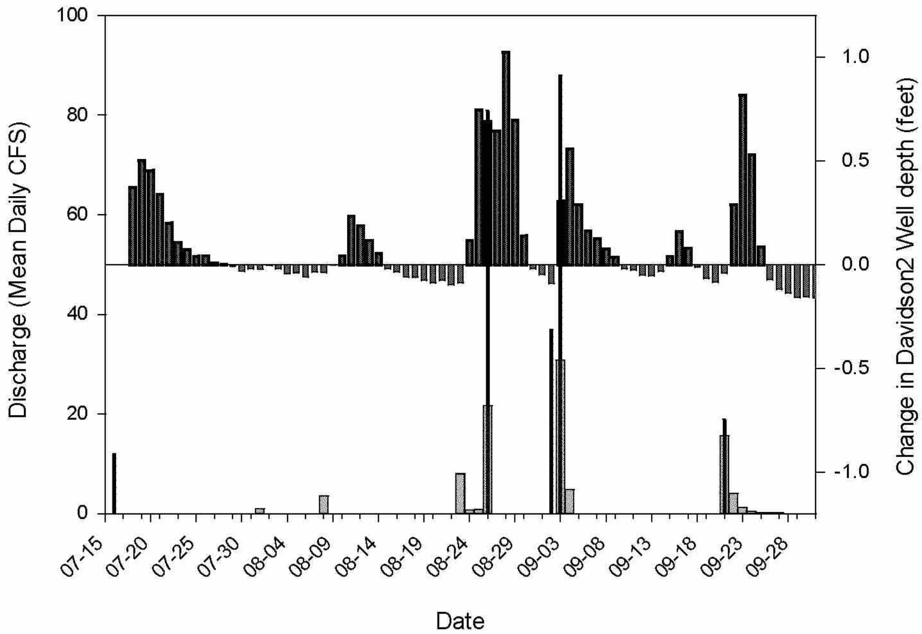

Figure 4. Same graph as Figure 2, but with the inclusion of discharge data from the Davidson Canyon ALERT gauge (solid black line).

A direct relationship between surface water flow and depth to water is evident for almost each period of time well depth increased. This phenomenon is preceded by stormflow in Davidson Canyon and/or measured flow in Barrel Canyon. An exception is an increase in recharge in the middle of September that is not associated with either of these measures, which also underscores the fact that there are many tributary inputs into Davidson Canyon below Barrel Canyon and not all of these may be recorded as stormflow at the Davidson Canyon Gauge.

We then took a more quantitative approach by looking at the daily change in well depth as a function of the relationship to stormflow, as measured at the Davidson Canyon Gauge. To do this we grouped change in well depth for each day into one of two categories in relationship to stormflow: 1) Yes(Y) = day was on or four days after a stormflow event or 2) No(N) = day was before or more than four days after a recorded stormflow event. The results show that there is strong statistical relationship between daily change in well depth and stormflow events (Fig. 5; 2-way t-test, t_{128} = 12.6, P =<0.0001, 95% confidence interval for "No" = -0.057 to -0.0014, "Yes" = 0.349 to 0.475). Thus, there is strong evidence for groundwater response at Davidson #2 well to storm water flow inputs recorded at the Davidson Canyon gauge.

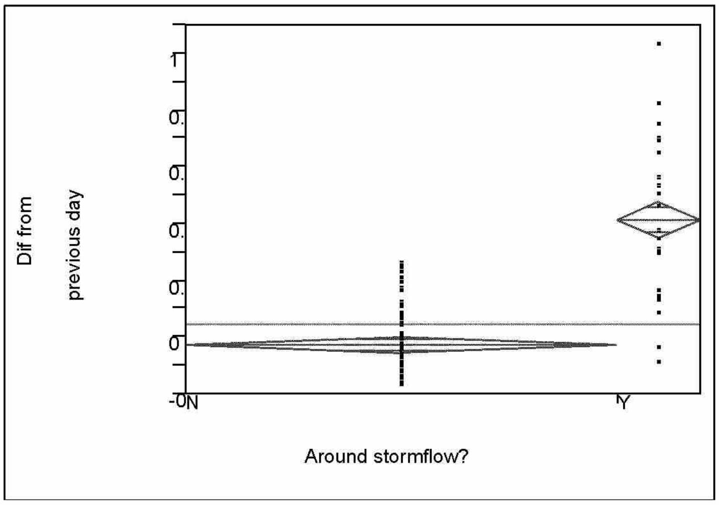

Figure 5. Daily difference in groundwater levels (as measured at the Davidson #2 Well) in relationship to stormwater events. (Y)es = on or four days after a stormflow event; (N)o before or more than four days after a recorded stormflow event.

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Because of the limited availability of high-resolution DTW data, this analysis looks only at monsoon and fall flows, not winter flows, which are more likely to include flows from Barrel Canyon than monsoon flows due to the difference between the smaller aerial extent of monsoon storms than winter storms.

<u>The relationship between streamflow length and depth to water in Davidson #2 Well remain strong</u>. In this memorandum we also update the analysis of data from Davidson Canyon relating streamflow length in miles to depth of water in the Davidson #2 Well. These data were first reported in Powell et al. (2014; Figure 5) and used data from 2005-2013. Since that time, we have obtained three new data points: June 2014 and September and November 2015. Figure 6 shows the results, indicating the relationship reported in 2014 holds today, though two of the three most recent observations are further above the regression line, meaning that flow lengths are shorter than would be predicted based on the DTW. An interesting note is that most other observations above the regression line (and where there is flow in Davidson) occur during fall and winter months.

We furthered our analysis of these data by adding three additional variables into a multiple linear regression analysis (depth to water as the response variable): month, year and month*year interactive effect. The resulting model accounted for 88% of the variation in the data (Fig. 7; $R^2 = 0.88$, $F_{9,29} = 16.96$, P =<0.001). Of course, the relationship to depth to water explained most of the variation (as reported in Figure 6),

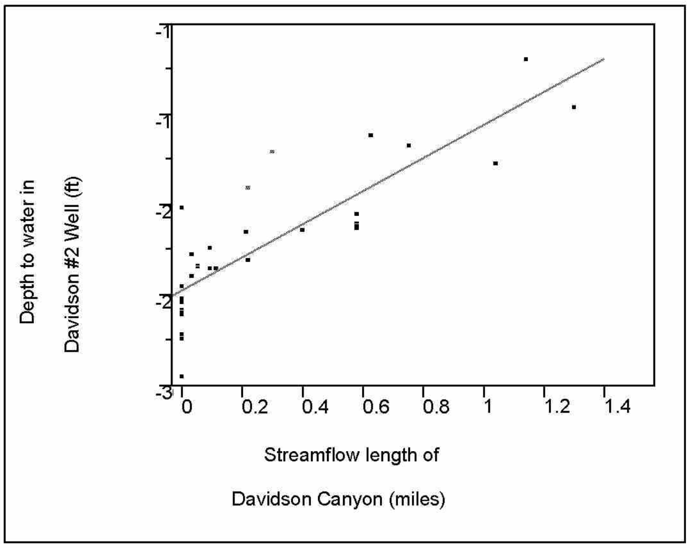

Figure 6. Relationship between length of flow in Davidson Canyon and depth to water at the Davidson #2 Well. The linear model (red line) explains 71% of the variation in the data. The most recent observations (green dots) are from September and November 2015.

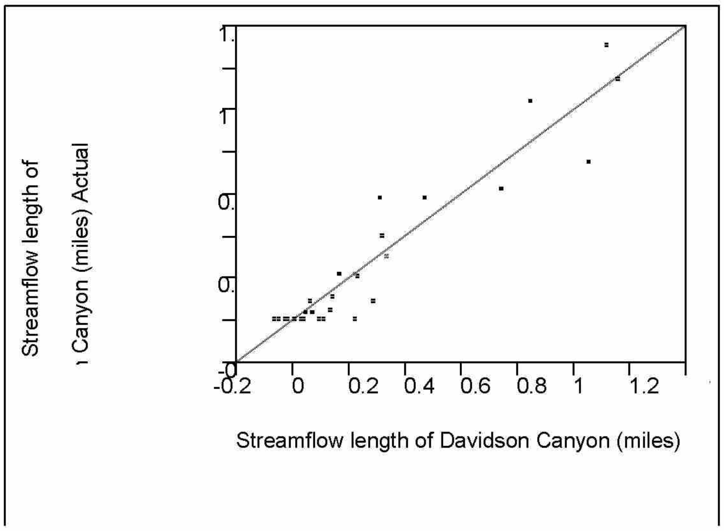

Figure 7. Relationship between length of flow in Davidson Canyon and other variables, from multiple linear regression model. The model (red line) explains 88% of the variation in the data. The most recent observations (green dots) are from September and November 2015.

but the September sampling period and September sampling * year were also statistically significant ($P < 0.01$). Year explained relatively little in the model, but during the period of analysis, presence of surface flow was relatively infrequent during the time period covered by the available data (i.e., 2005 and later). Especially before 2005, visits by Pima Association of Governments staff and others noted perennial water in Davidson Canyon in the winter and spring (Pima Association of Governments 2005), which highlights both the current drought conditions and the historical winter flow in Davidson Canyon.

In summary, our analysis found:

1) Barrel Canyon provides a disproportional amount of surface water within the Davidson Canyon watershed. This is not surprising that most of the high elevations areas of the watershed drain into Barrel Canyon and considering the orographic effect.
2) The shallow groundwater aquifer in Davidson Canyon, in which Davidson #2 Well is embedded, is highly responsive to pulses of surface water flow, whether it be baseflow or stormflow. This relationship was evident from the qualitative observations (Figs. 2-4) and quantitative analyses (Fig. 5). Yet, analysis of the impacts of the proposed Rosemont project on Davidson Canyon and Cienega Creek does not take into account this relationship. Further analysis of winter

precipitation in 2015-2016 using the new dataset at the Davidson #2 Well (intra-day well depths) will provide valuable insight into this important relationship.

3) The new analysis of the relationship between depth to water and length of streamflow in Davidson Canyon, which used three new data points, reaffirms an earlier analysis by Powell et al. (2014) for a strong statistical relationship between these two variables. That is, as groundwater levels rise and fall, so too does the length of flow in Davidson Canyon increase and contract (Fig. 6);
4) Failure to understand the connection between surface water in Davidson Canyon and to account for its loss because of surface water diversions by the Rosemont Mine could lead to irreparable harm to groundwater resources that are critical to the proper hydrological conditions and functions that sustain vegetation and surface water and to the wildlife that depend on these critical resources.

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